

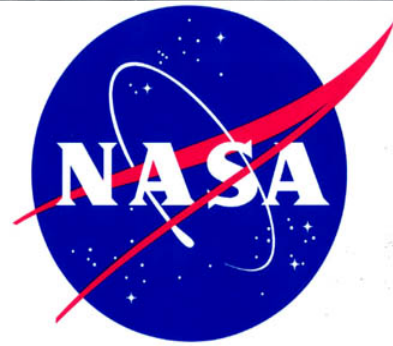
Satellite Driven Studies of Climate Mediated Changes in Antarctic Food Webs

April 25, 2012

Matthew Oliver, Megan Cimino, Andrew Irwin, William Fraser, Josh Kohut, Oscar Schofield, Mark Moline, et al.



RUTGERS
CAL POLY



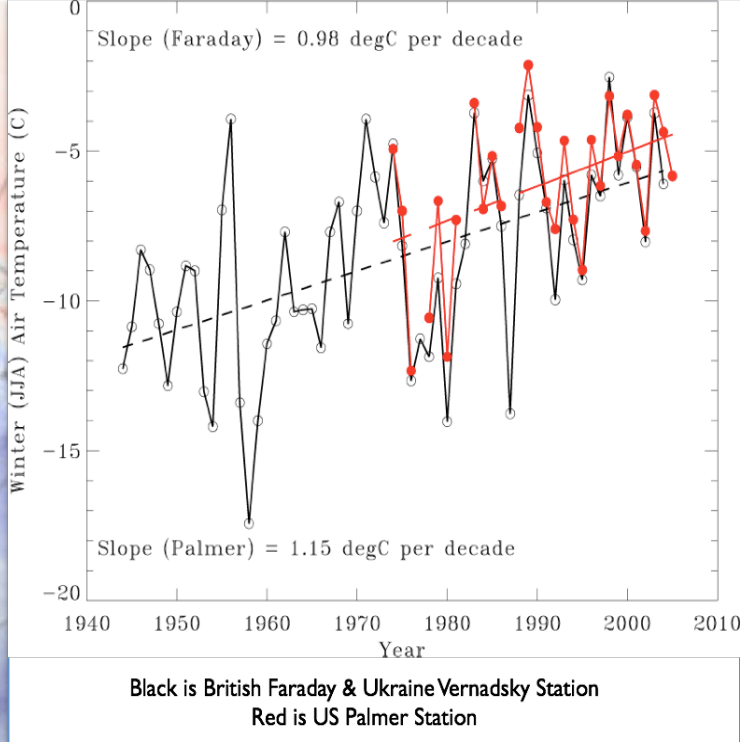
Background

—Antarctic Peninsula

West Antarctic Peninsula (WAP) is the undergoing the fastest winter warming on Earth (Vaughan et al. 2003)

Mean winter air temperature increased by 6°C since 1950

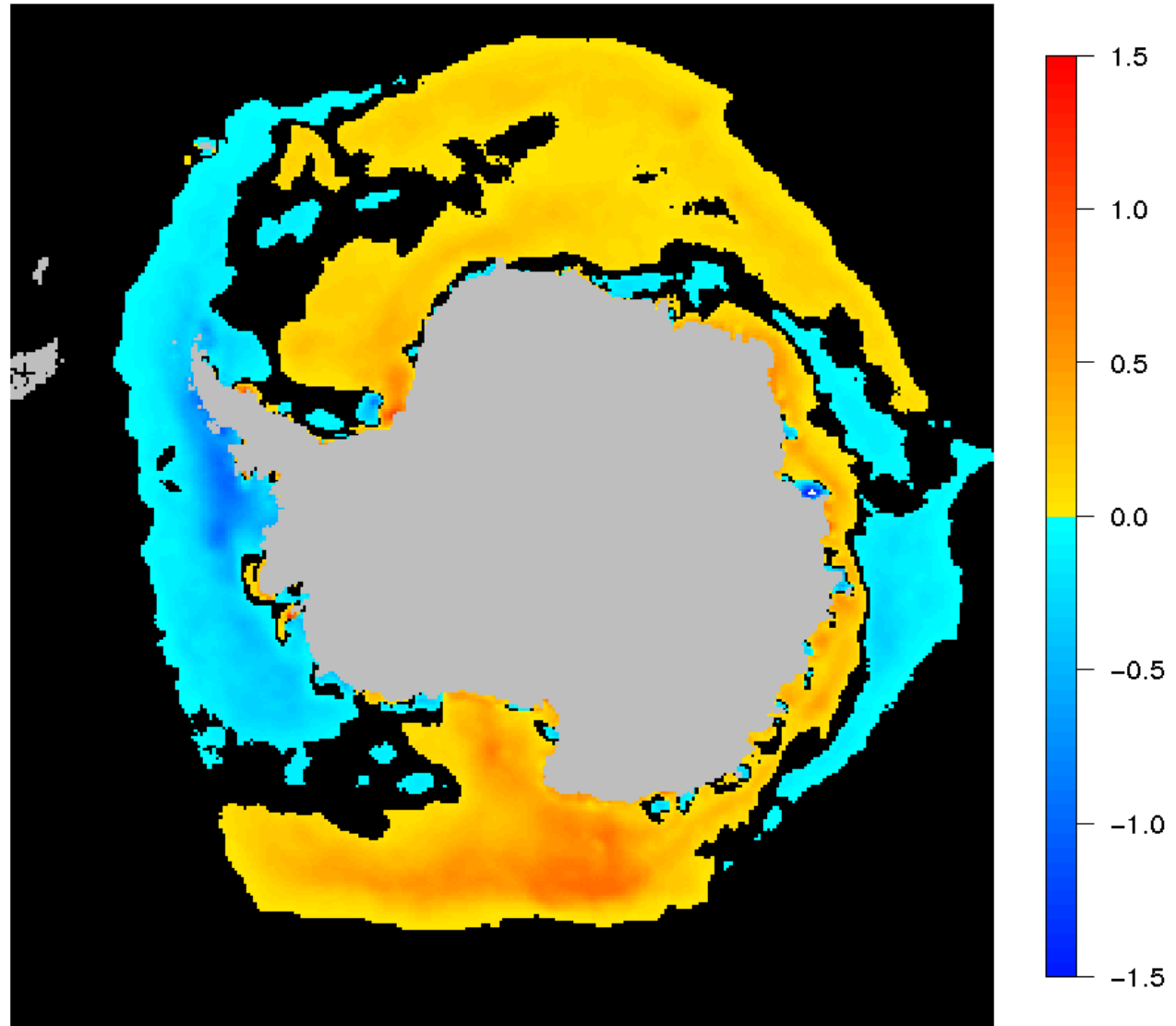
—Ross Ice Shelf—



Temperature Anomaly



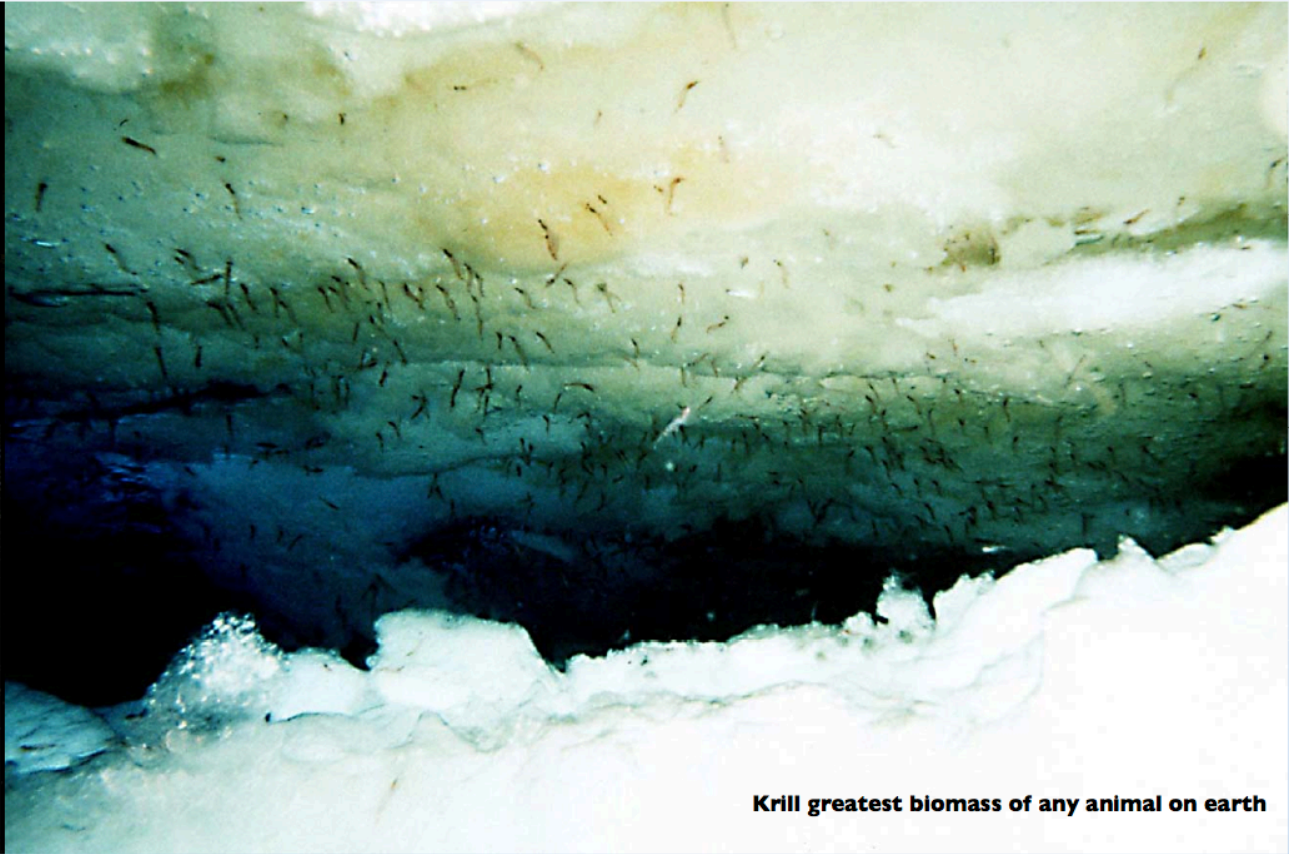
Annual Rate of Sea Ice Concentration change (%)
1978–2008



Also a Large
Change in Sea Ice
Concentrations

Background

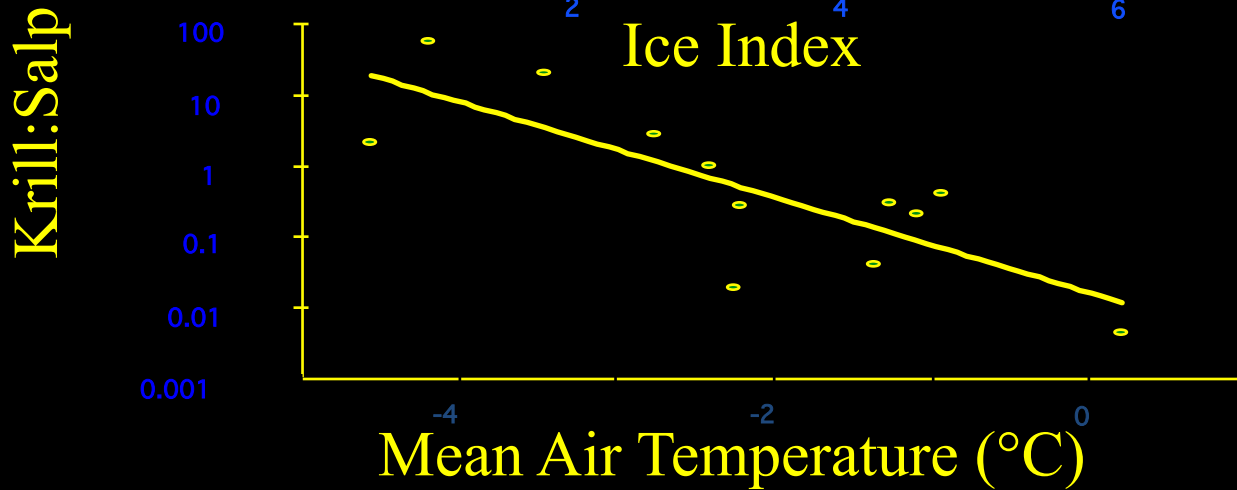
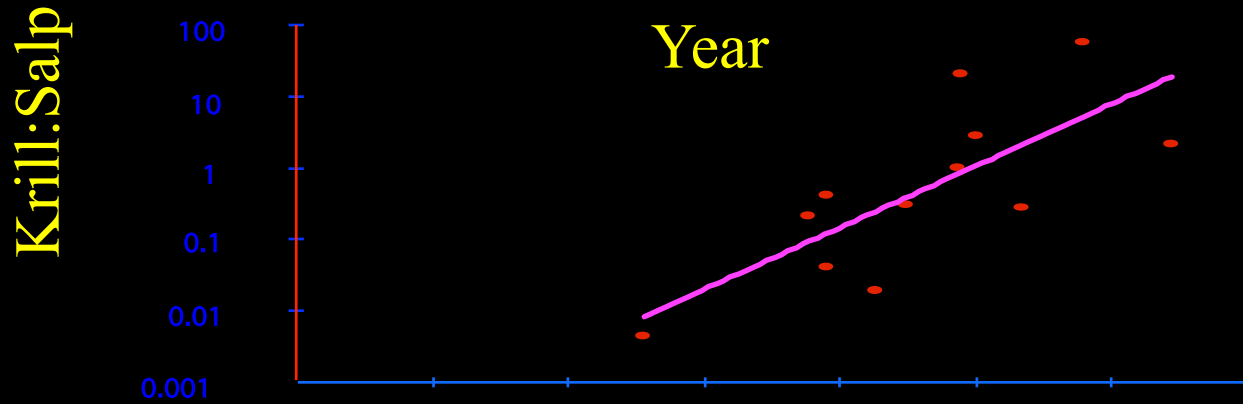
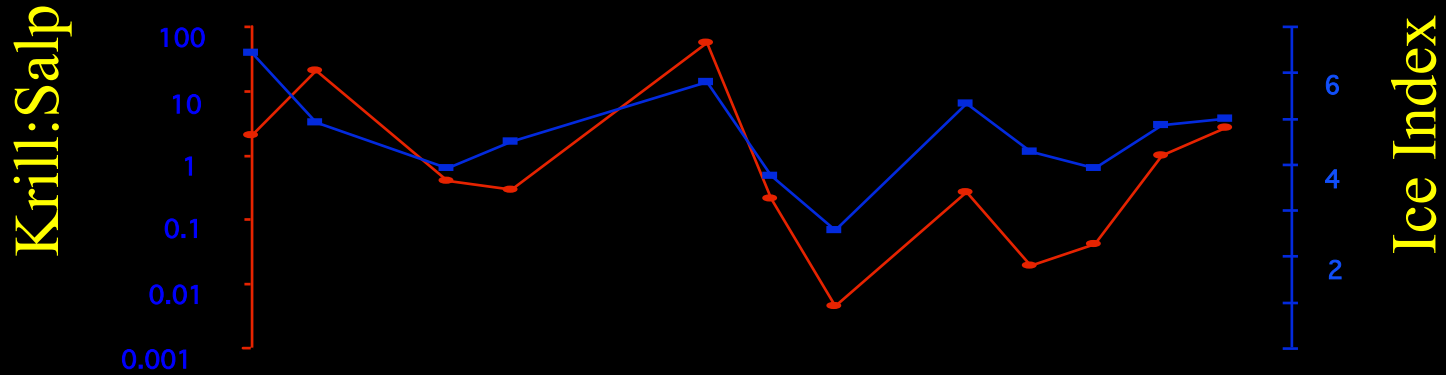
These changes alter the base of the food chain



Krill greatest biomass of any animal on earth

Background

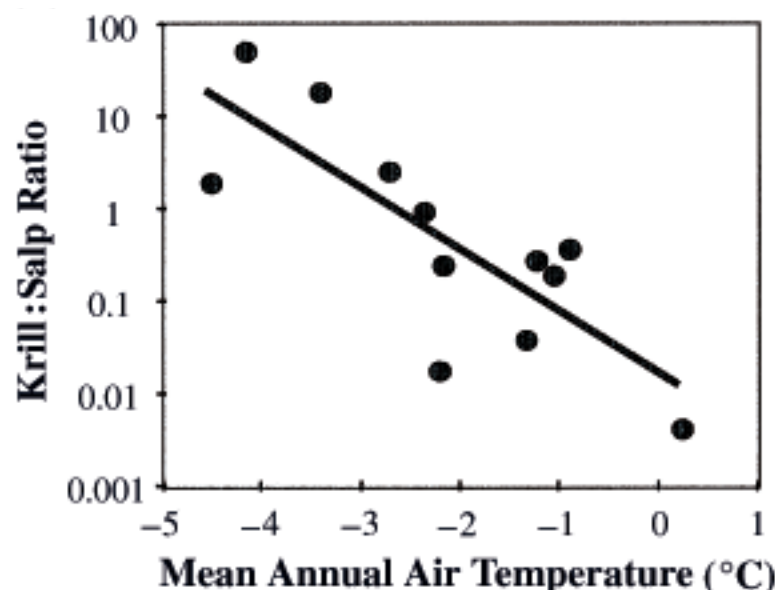
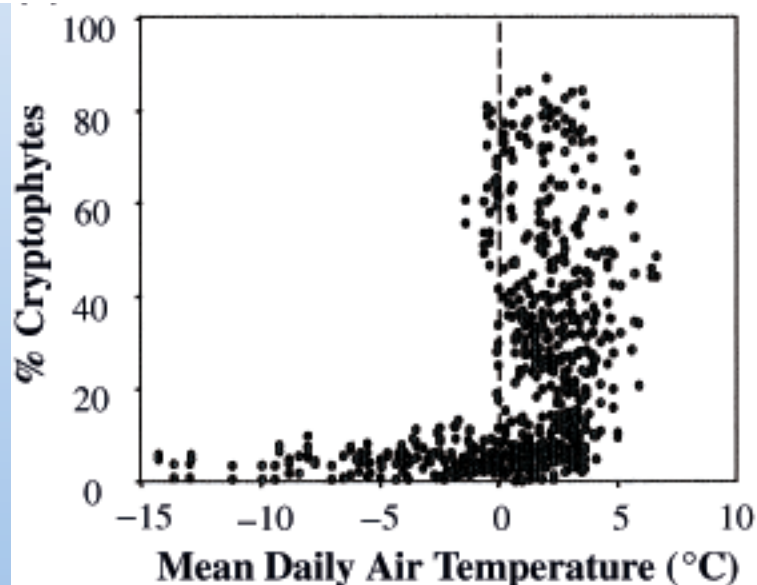
From *Loeb et al., 1997*



Alteration of the food web along the Antarctic Peninsula in response to a regional warming trend

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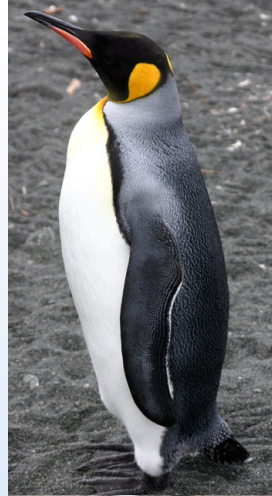
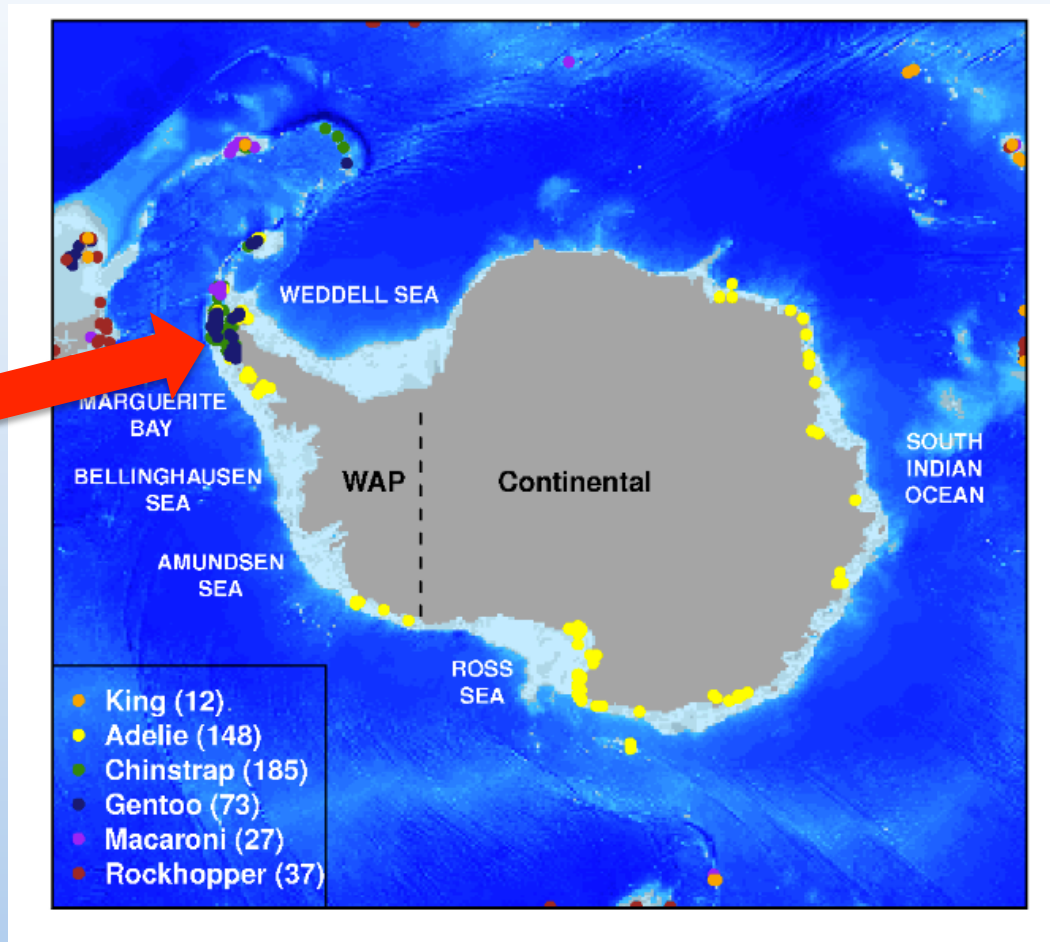
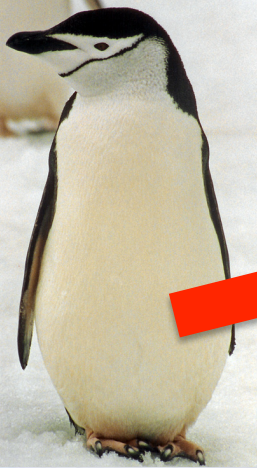




Adélie penguins form rookeries in fixed locations year after year. Rookeries are formed and breeding pairs raise their young. For their young the parents need a predictable food resource that can be ascertained in a less than a days swim (December-February)



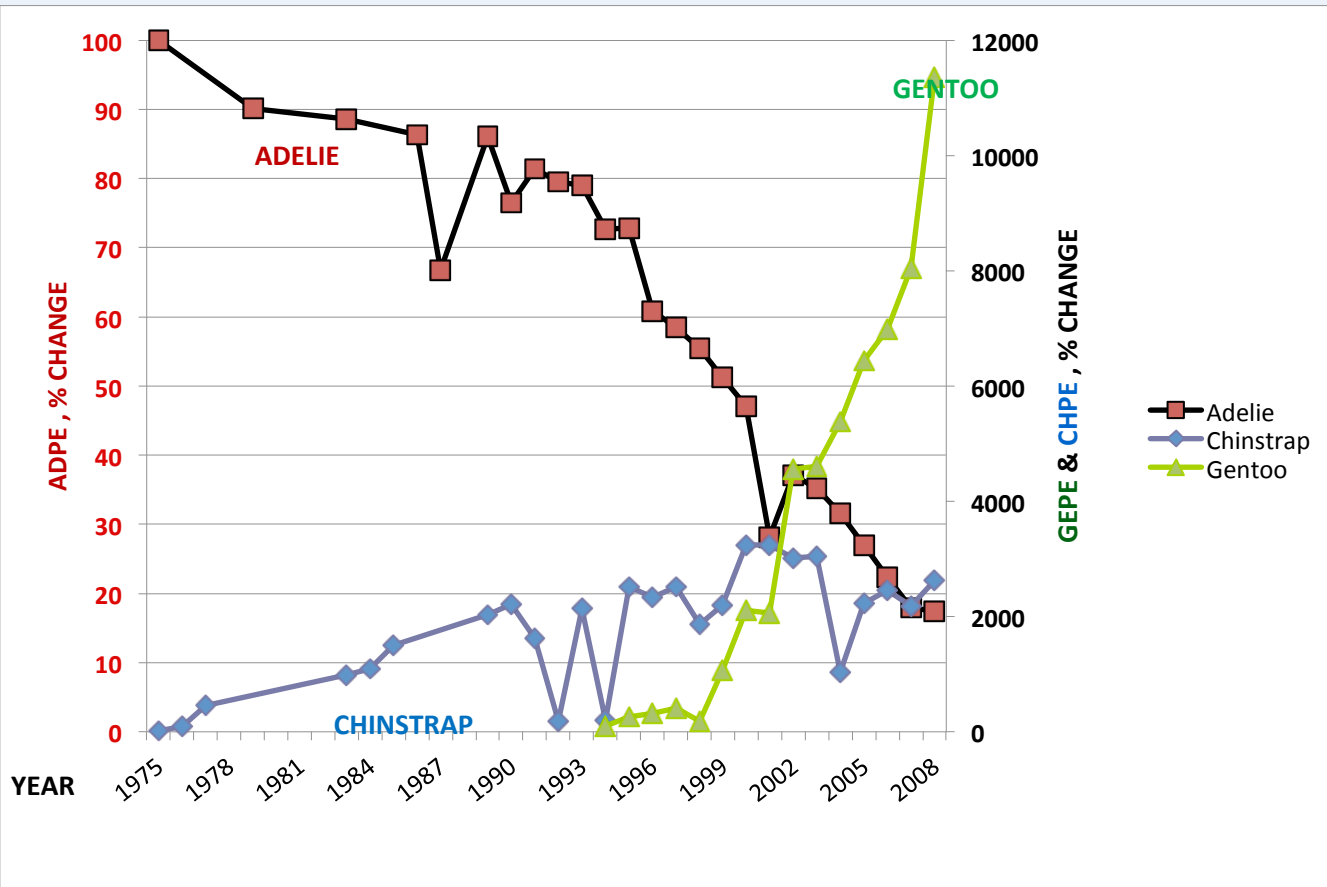
Distribution of Antarctic and sub-Antarctic Penguins



Location of 521 Antarctic and sub-Antarctic penguin breeding colonies in the Southern Ocean. The number of unique breeding locations for each species given in parenthesis.

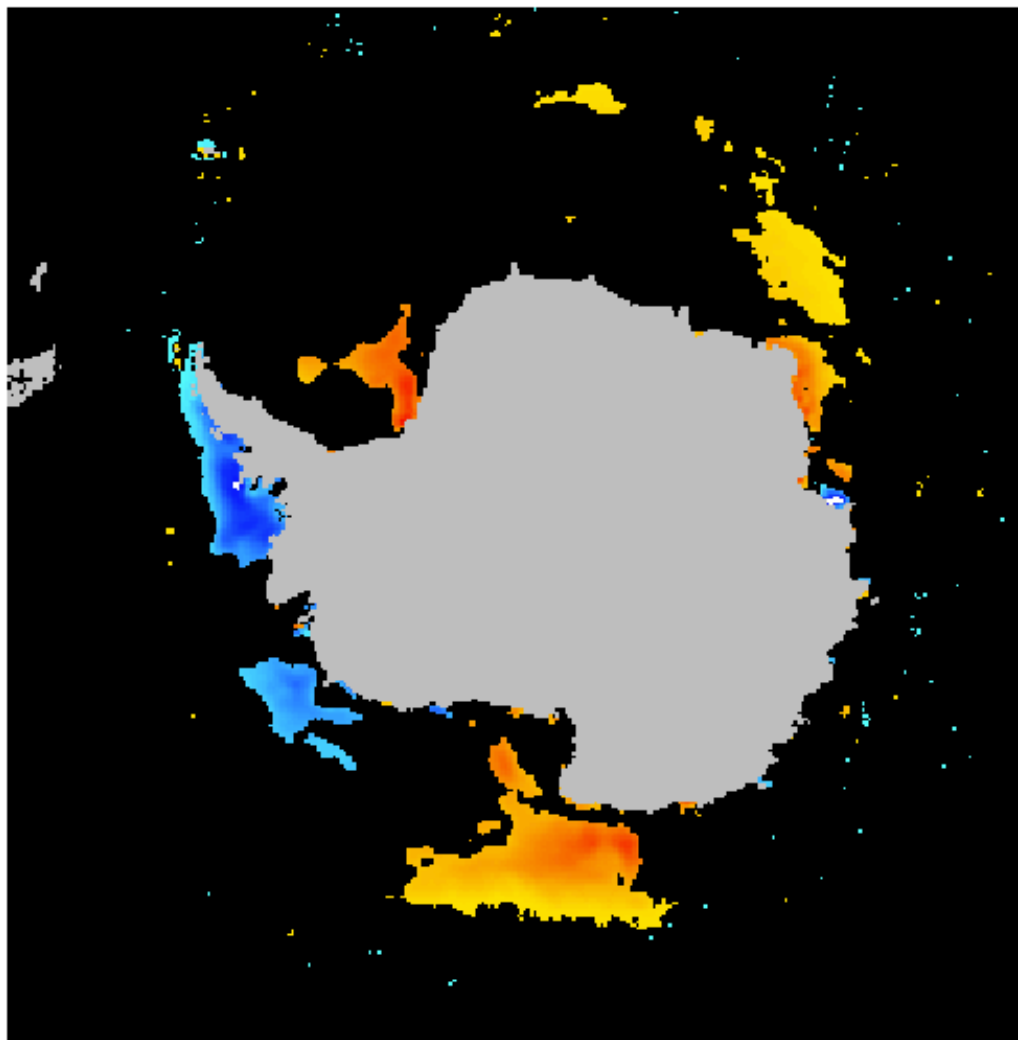
Background

Major changes seen in the upper trophic levels at Palmer Station in the West Antarctic Peninsula



Changes in Environmental Parameters...

Change in Sea Ice Percent: Dec-Feb 1978-2010



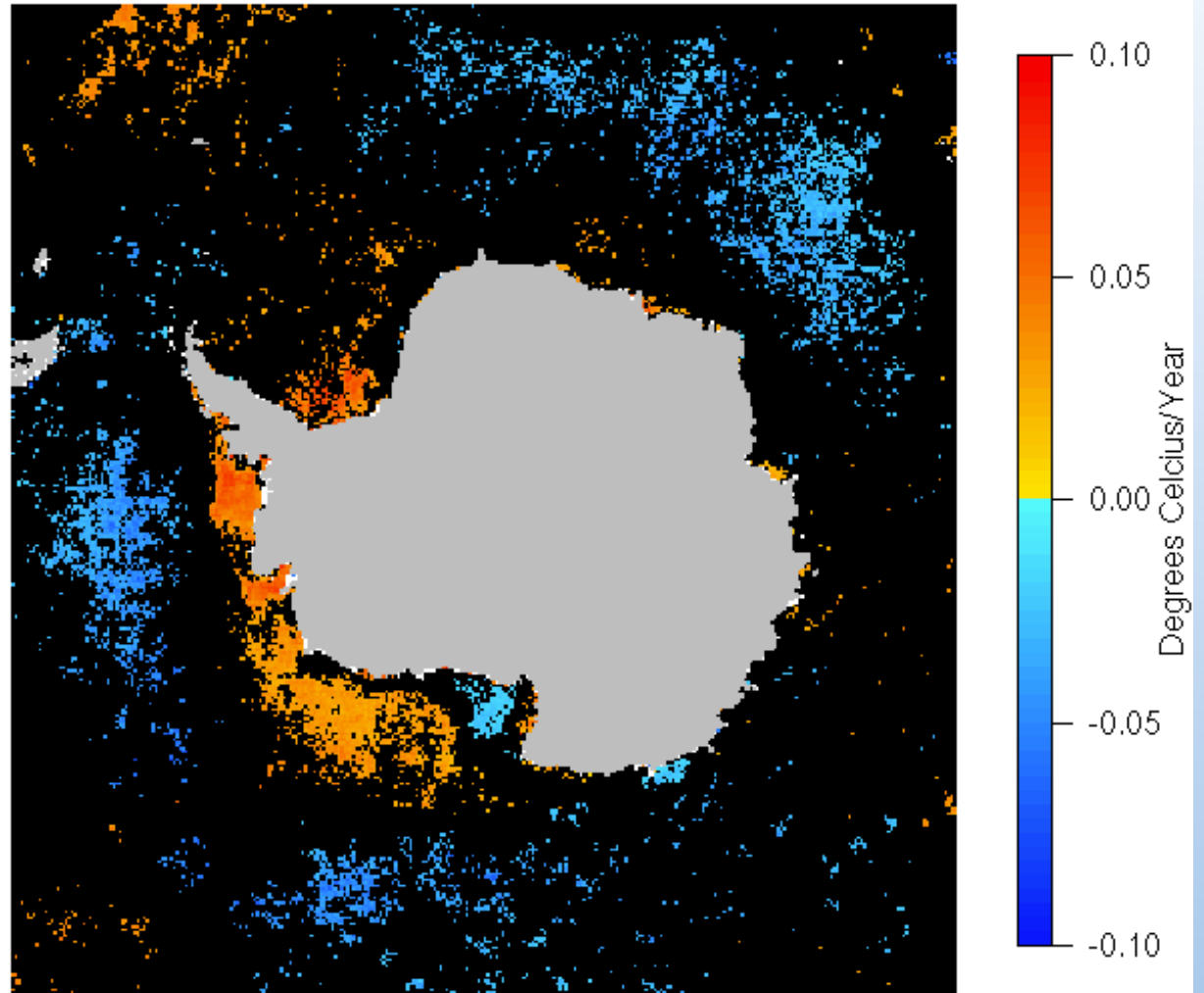
Percent Change/Year

**Focus on Important
Breeding Months**

**Large Scale Remote
Sensing/Modeling**

Changes in Environmental Parameters...

Changes in SST: Dec-Feb 1981-2010

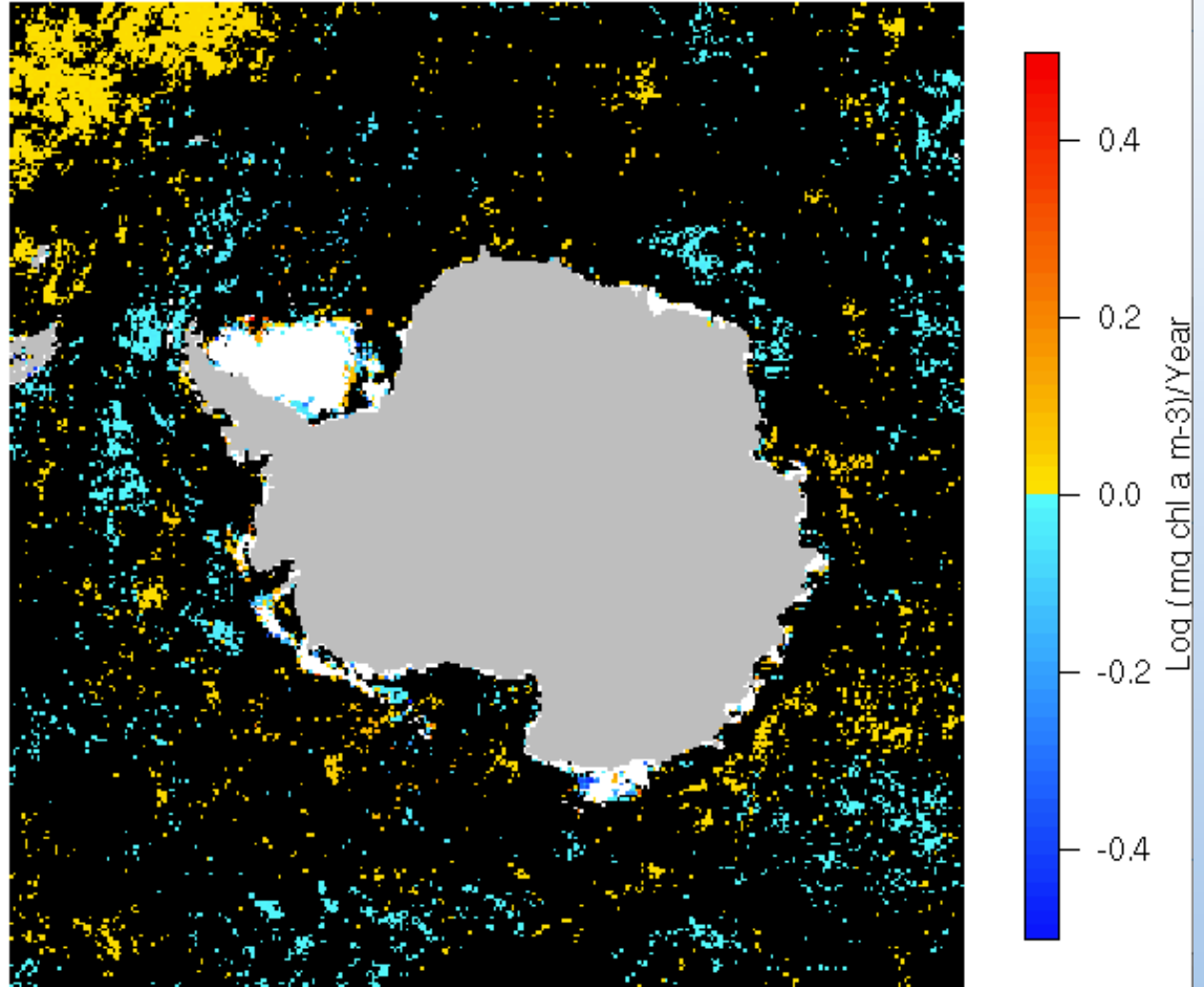


Focus on Important
Breeding Months

Large Scale Remote
Sensing/Modeling

Changes in Environmental Parameters...

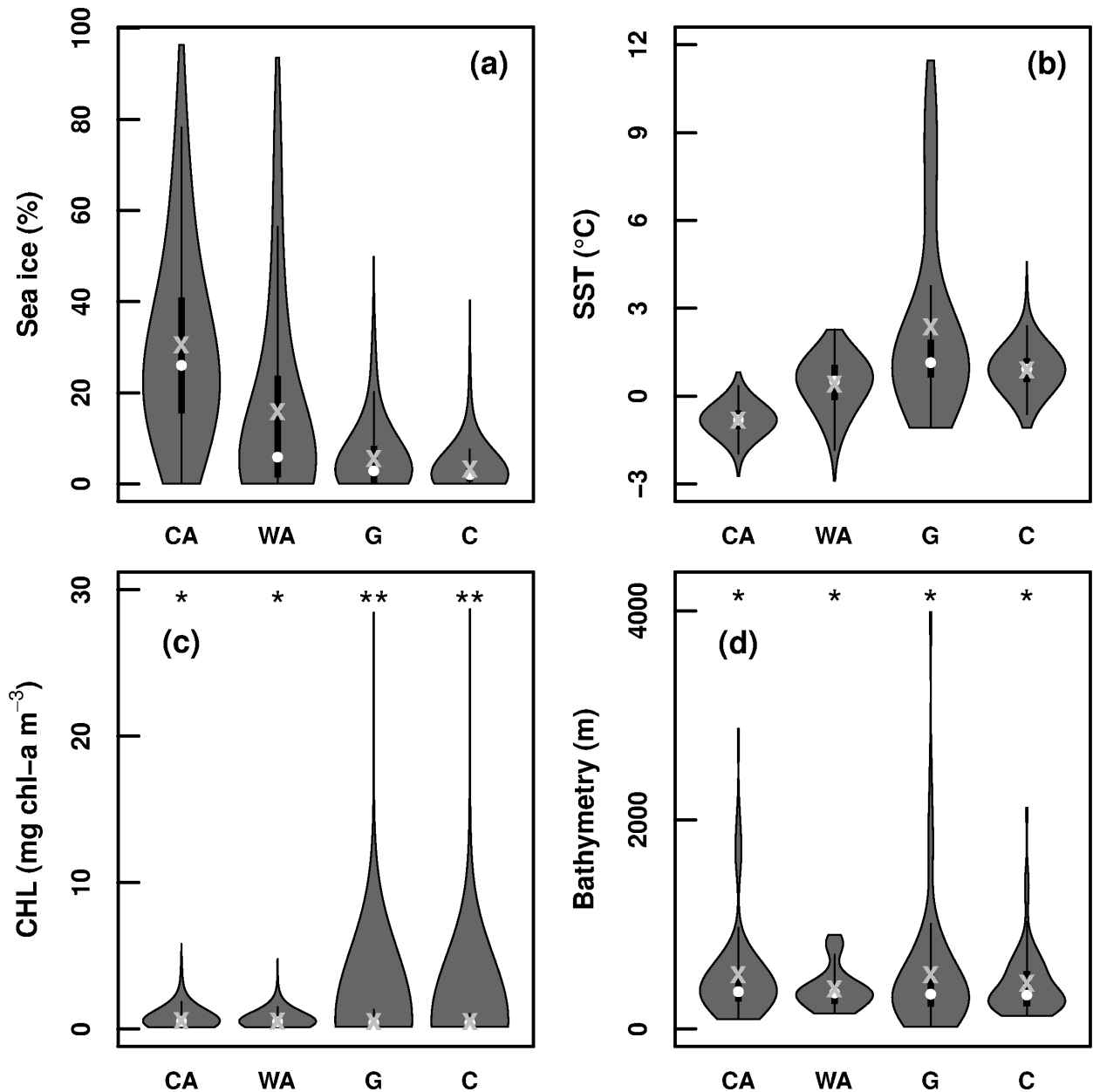
Changes in log CHL: Dec-Feb 1978-1986, 1997-2010



Focus on Important
Breeding Months

Large Scale Remote
Sensing/Modeling

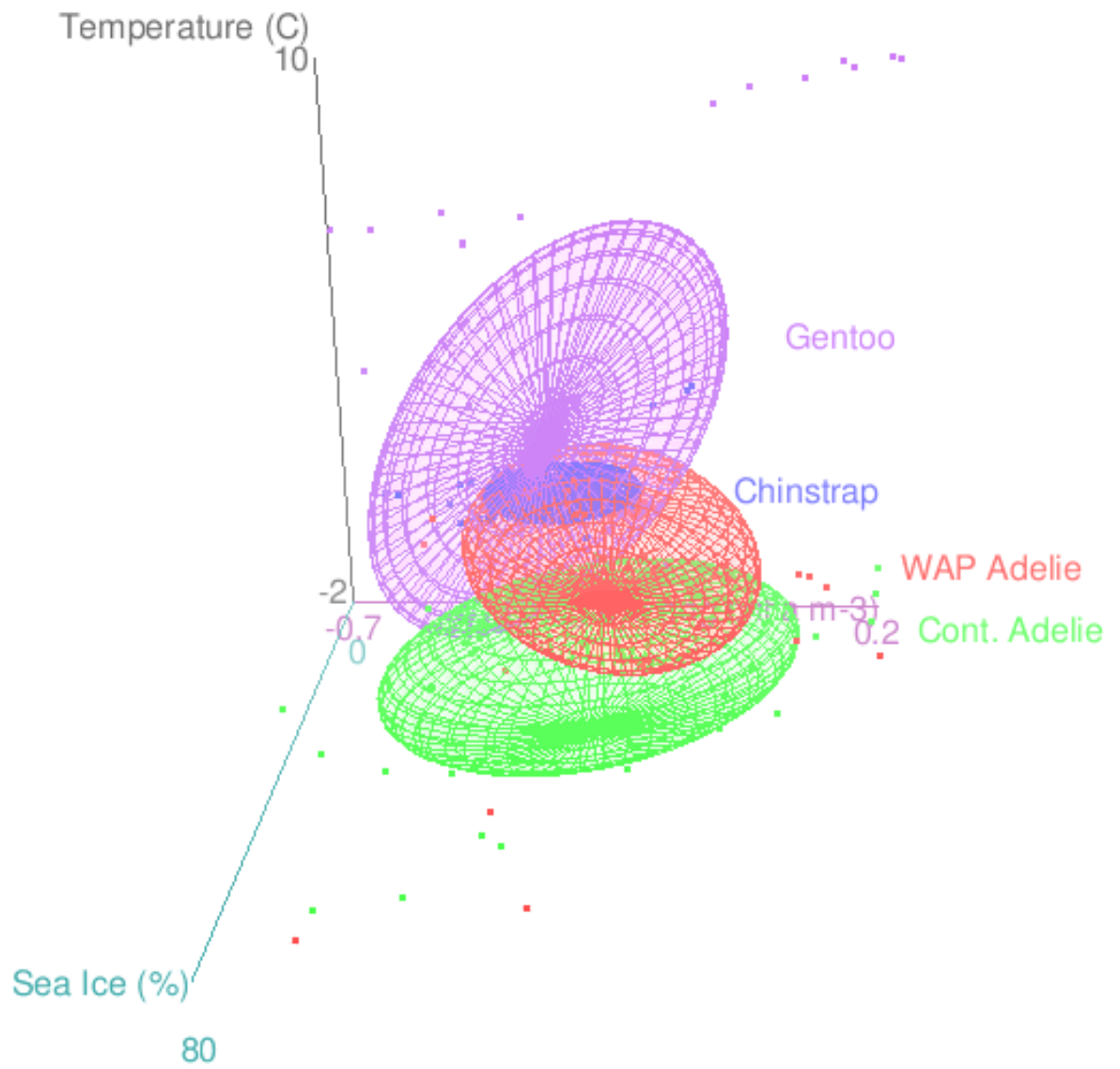
Characterizing Penguin Breeding Locations



CA= Continental Adélie
WA= WAP Adélie
G= Gentoo
C=Chinstrap

Large Scale Remote
Sensing/Modeling

Large Scale Remote Sensing/Modeling

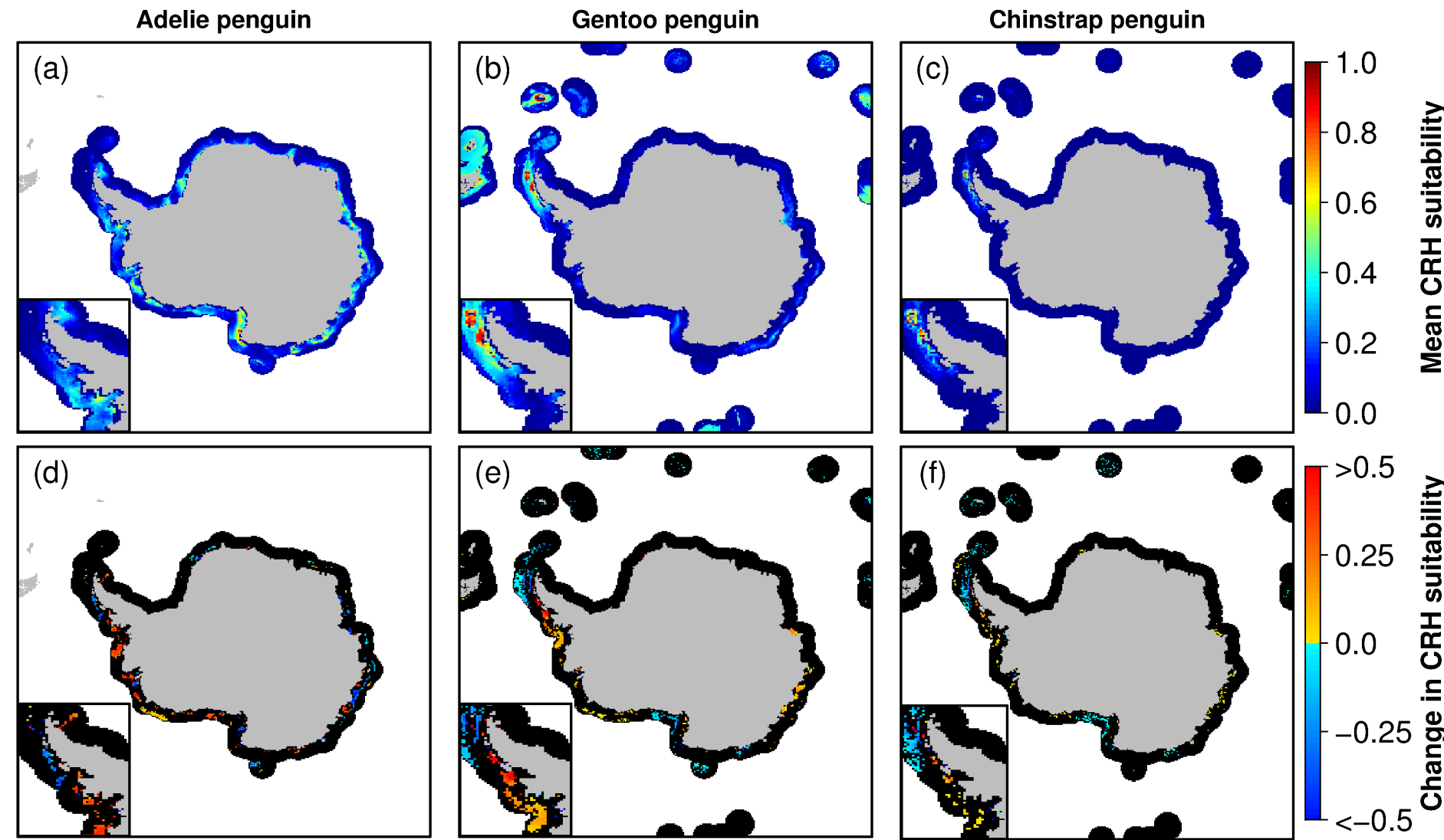


Methods

Penguin Breeding Habitat Models

- MaxEnt: maximum-entropy approach for species habitat modeling
 - Estimates the probability distribution based on the environment constraints throughout the study region by finding the probability distribution of maximum entropy
- Niche-based model that represents ecological niches by the environmental variables tested
 - Train model with colony locations & predictor variables from 1978-1984, predict onto each year from 1985-2010

Results

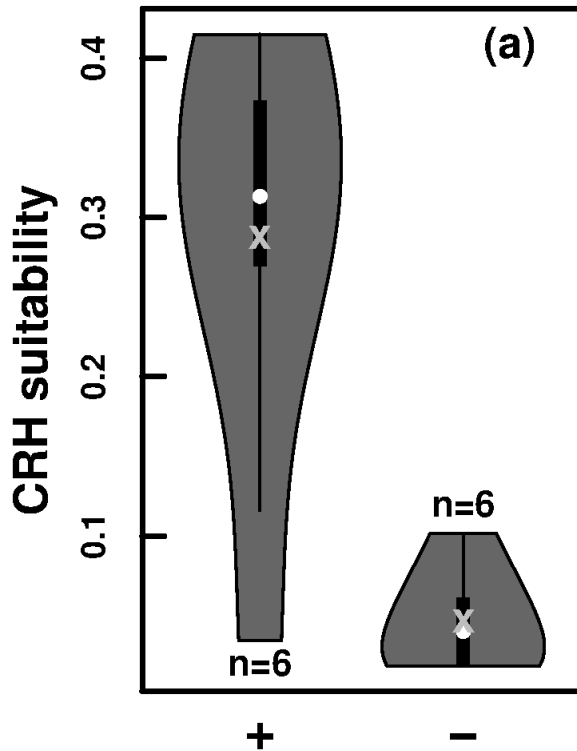


Results

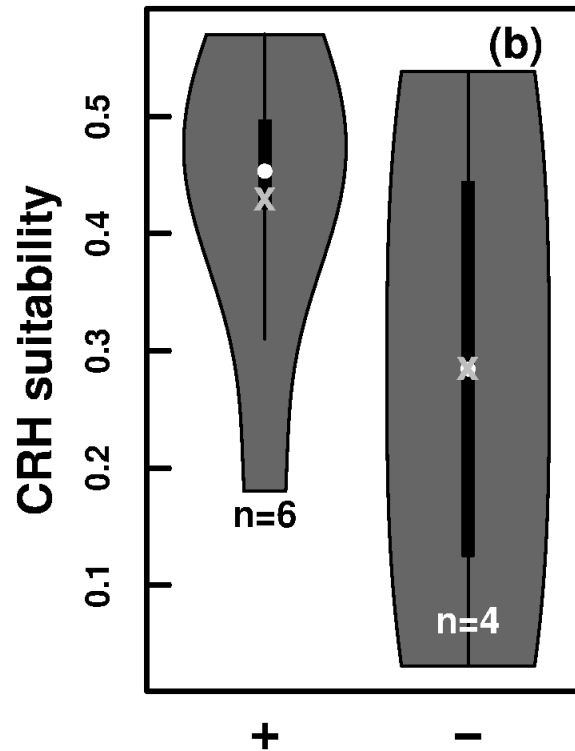
Matching penguin habitat suitability to population trends

Fine scale processes still important

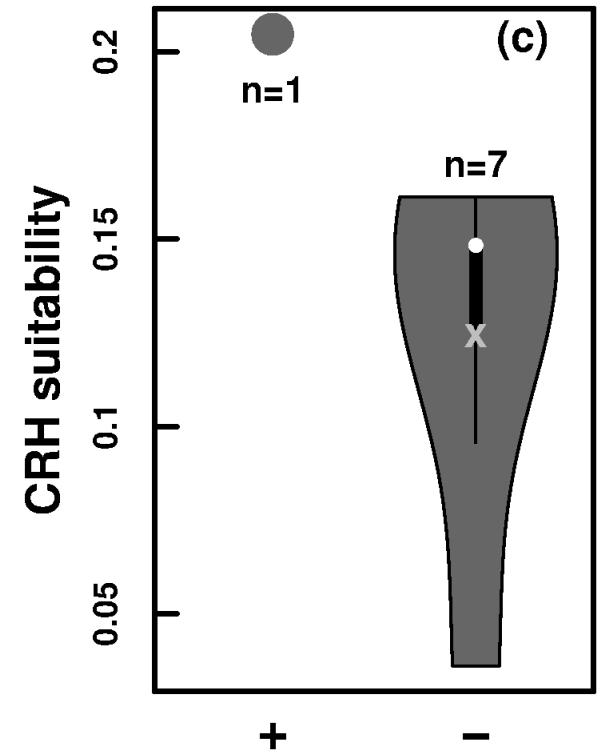
Adelie



Gentoo



Chinstrap



Torgersen Island 1991
Photo: Mark Moline



Torgersen Island 2011
Photo: Mark Moline



First Field Season



The Plan



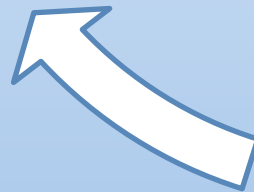
Assessment

Satellite
Tags



Deployment

ARGOS
Position

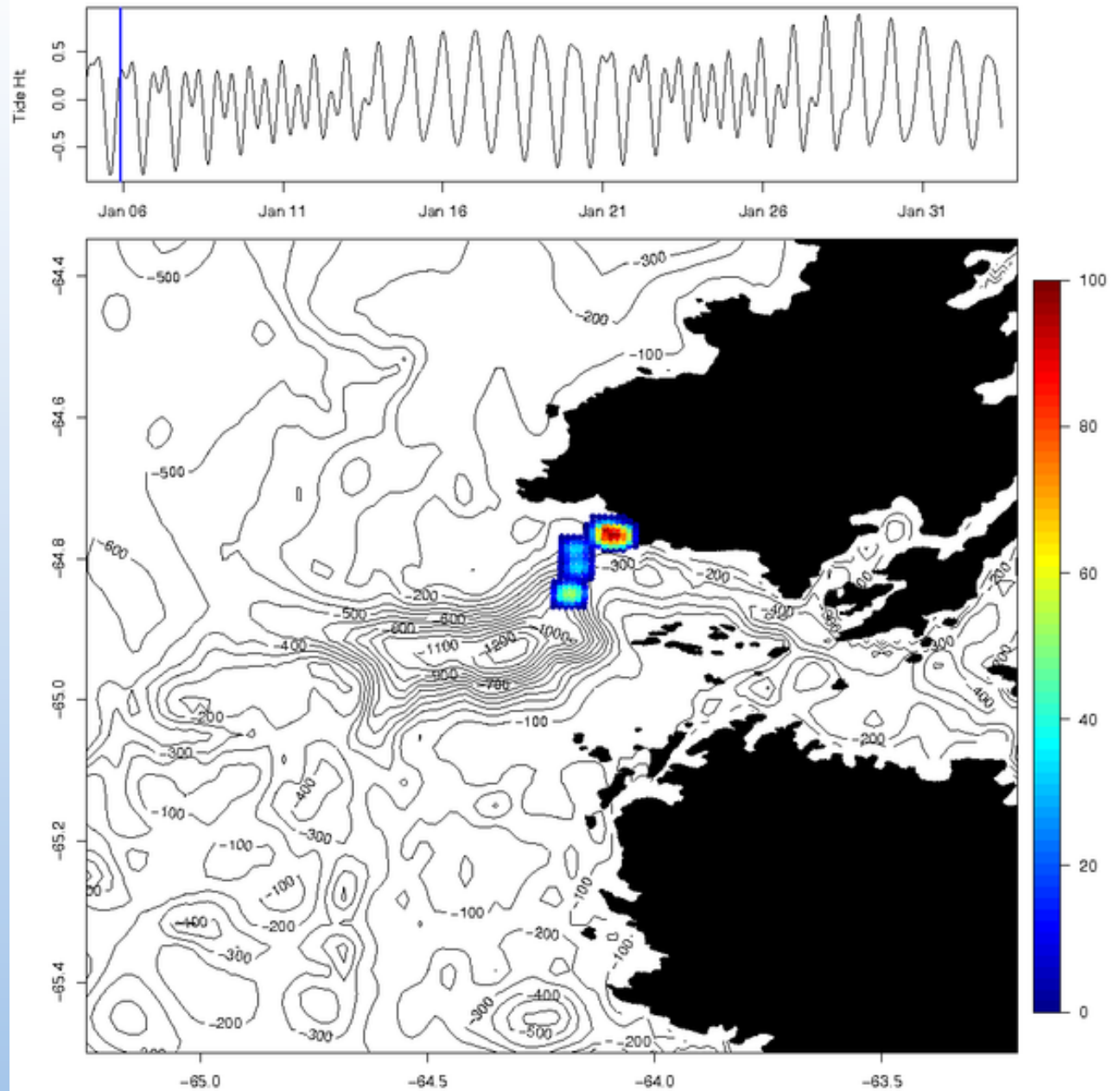


Mission
Planning



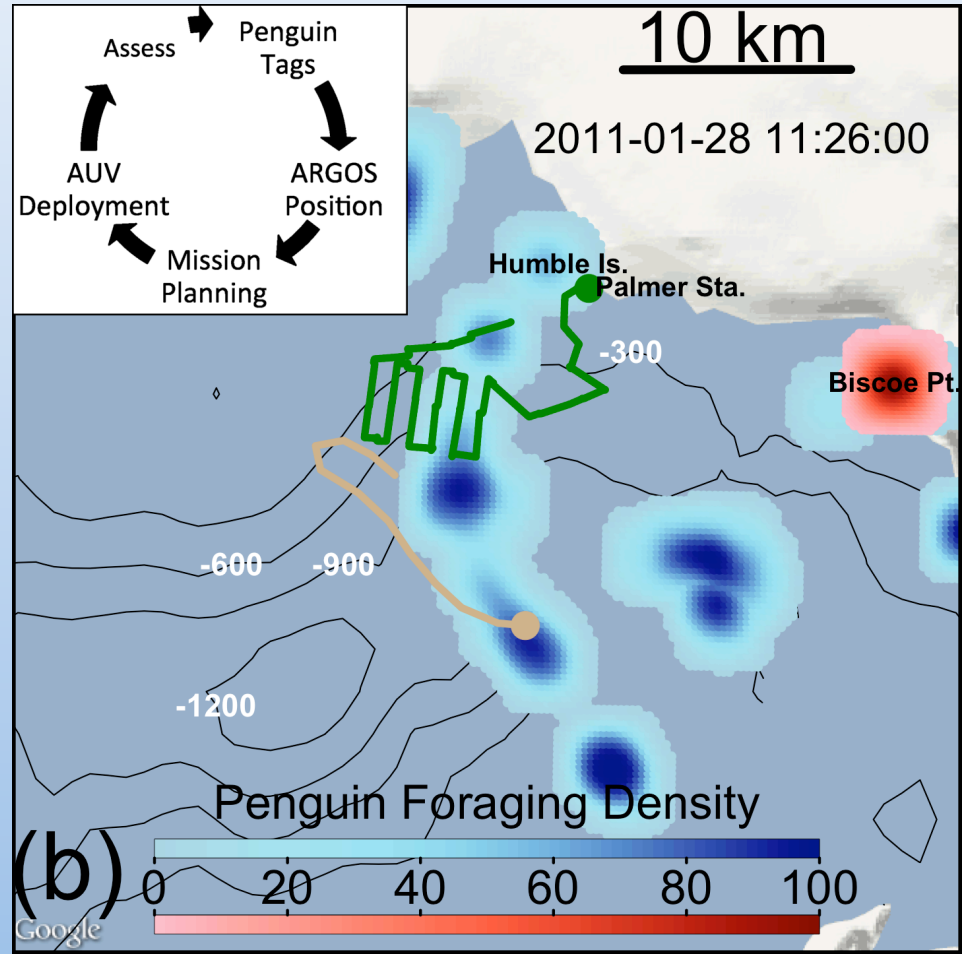
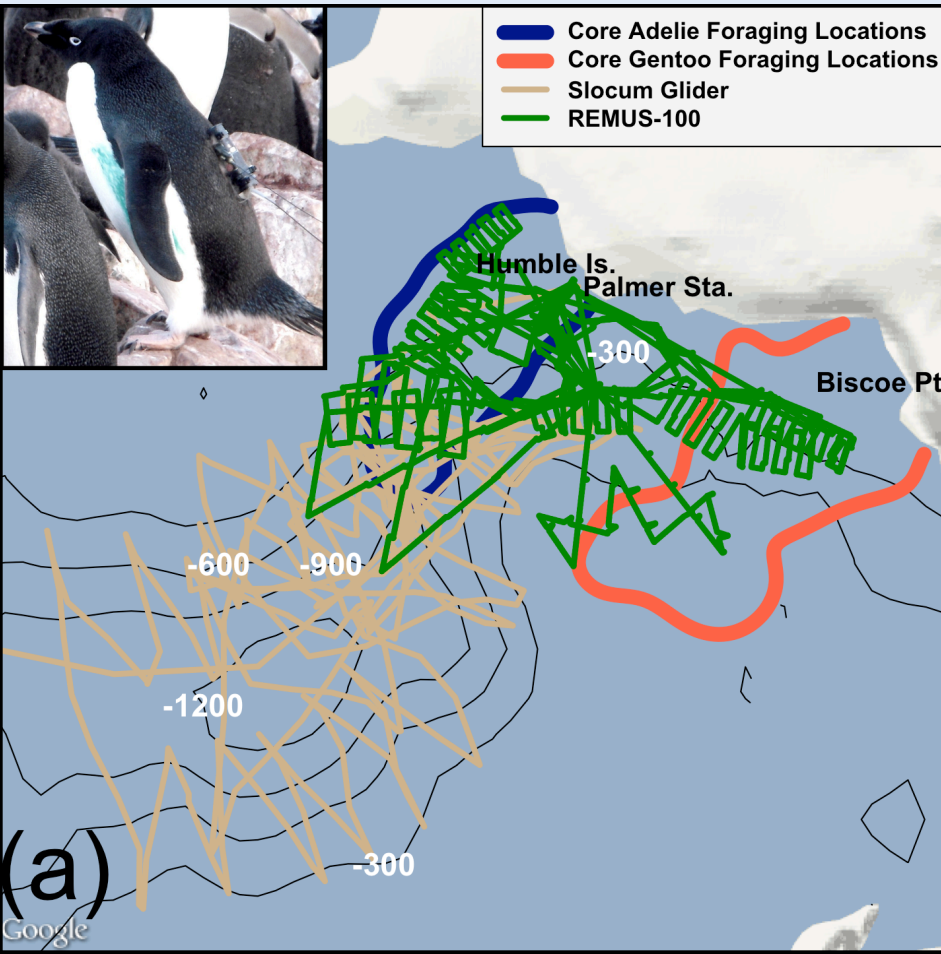
First Field Season

Near-Real Time Mapping of Penguin Foraging Locations



The Dance!

Targeted sampling of penguin foraging locations



First Field Season

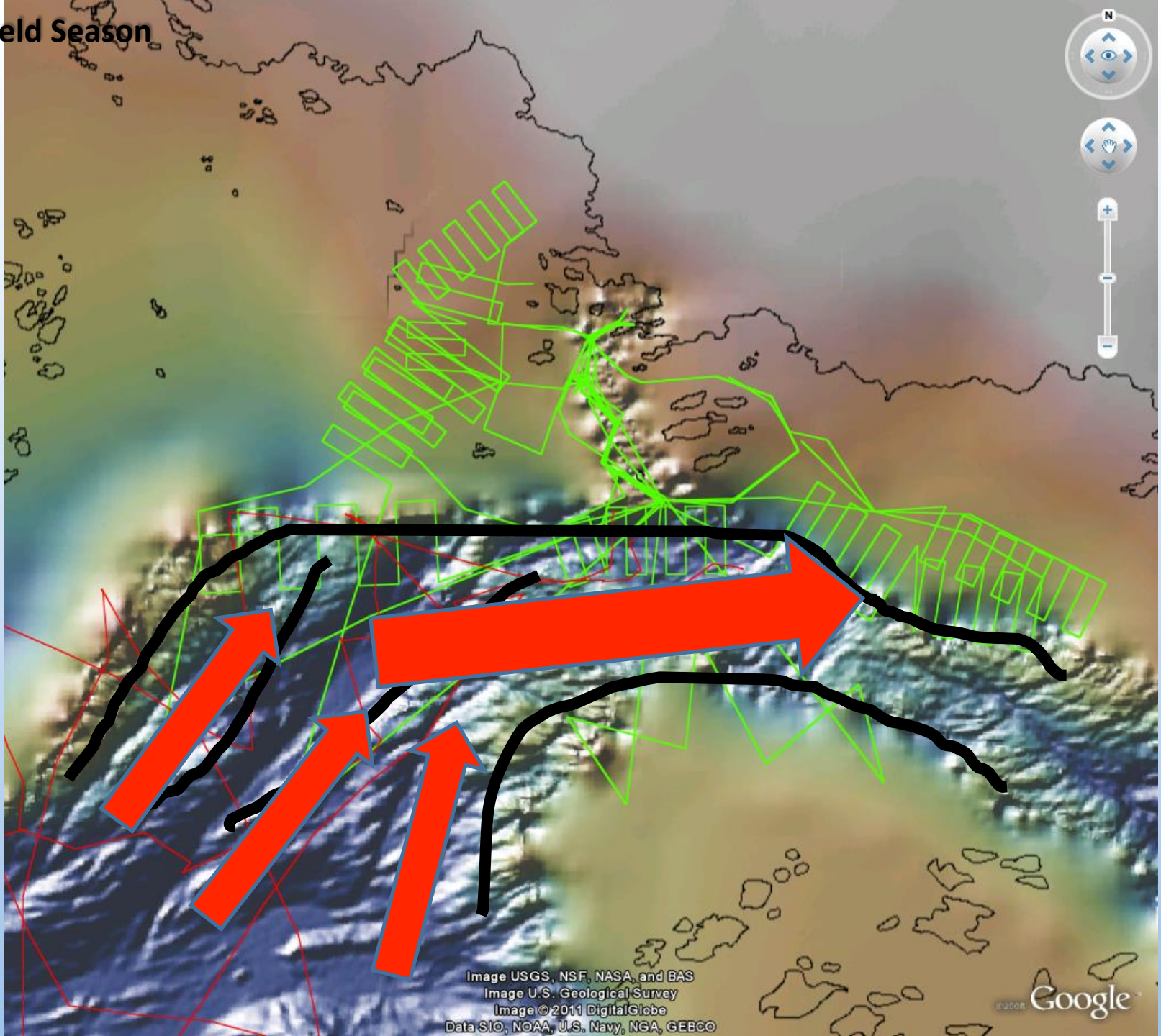
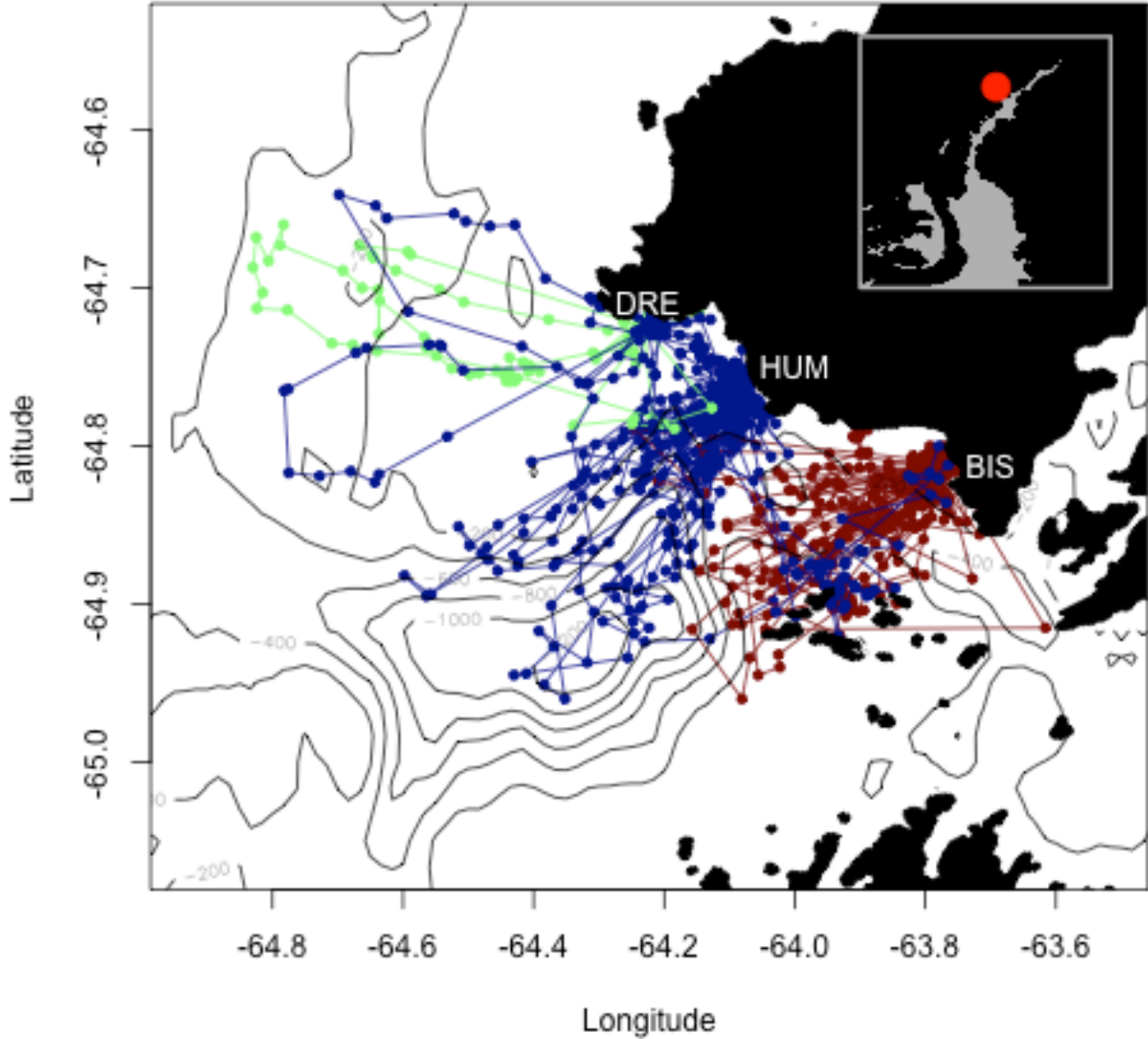


Image USGS, NSF, NASA, and BAS
Image U.S. Geological Survey
Image ©2011 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google

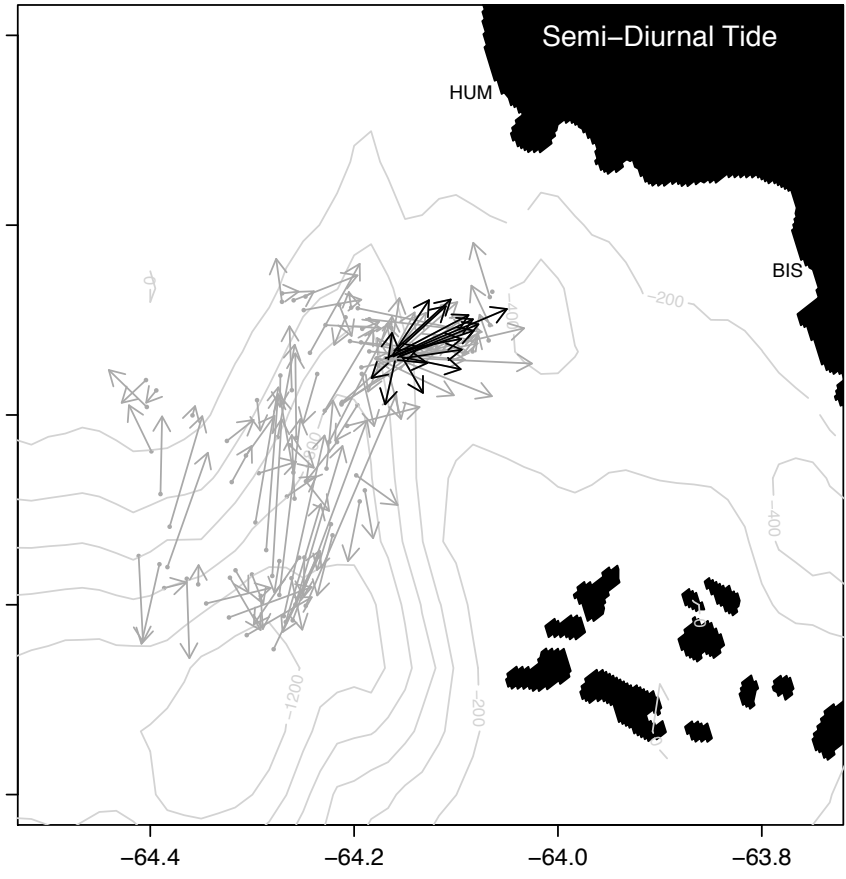
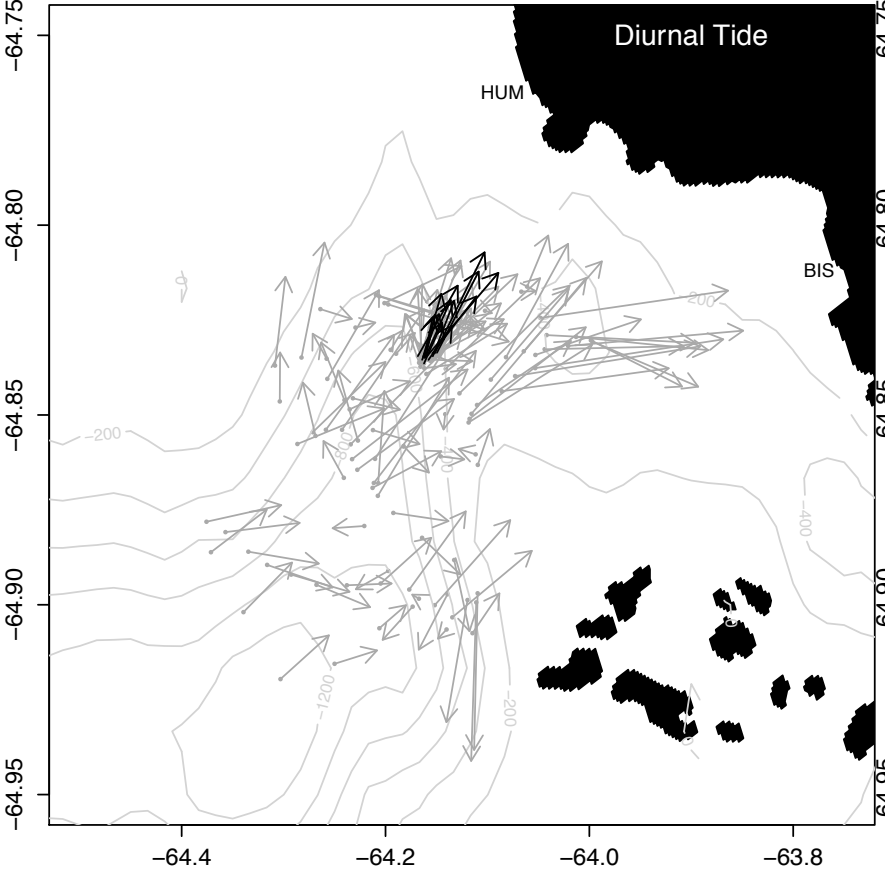
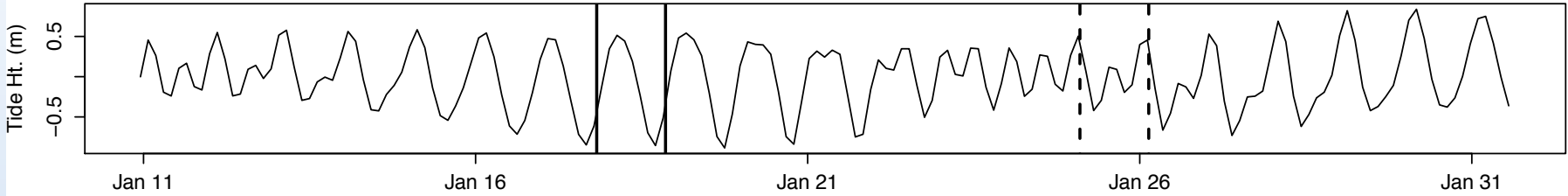
First Field Season Results

Filtered Adélie (blue),
Gentoo (red) and
Chinstrap (green)
penguin satellite tracks
located at Humble
island (HUM), Dream
Island (DRE) and Biscoe
Pt. (BIS)



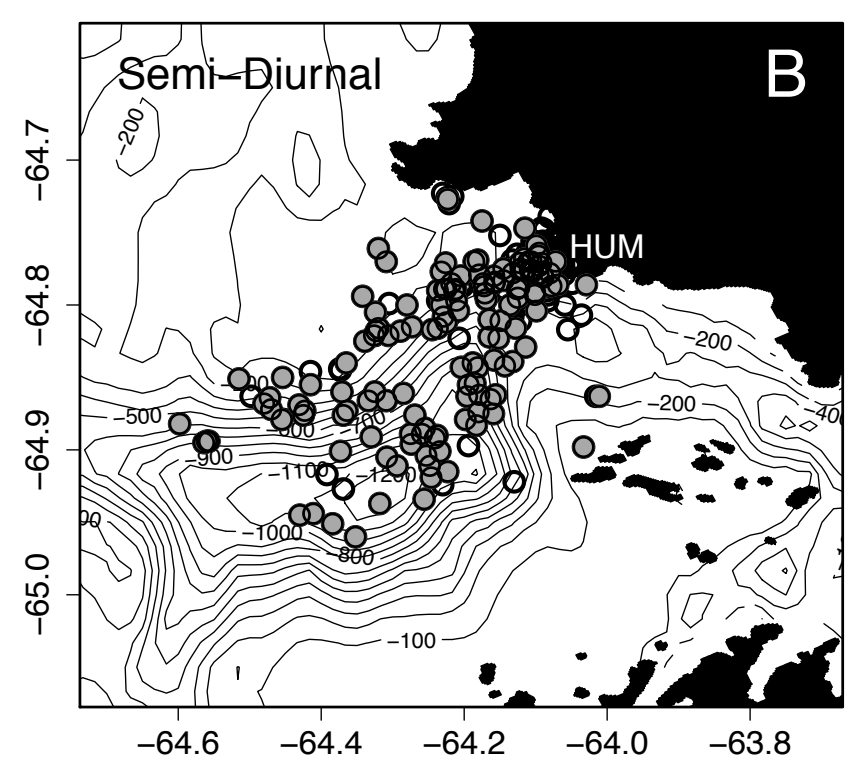
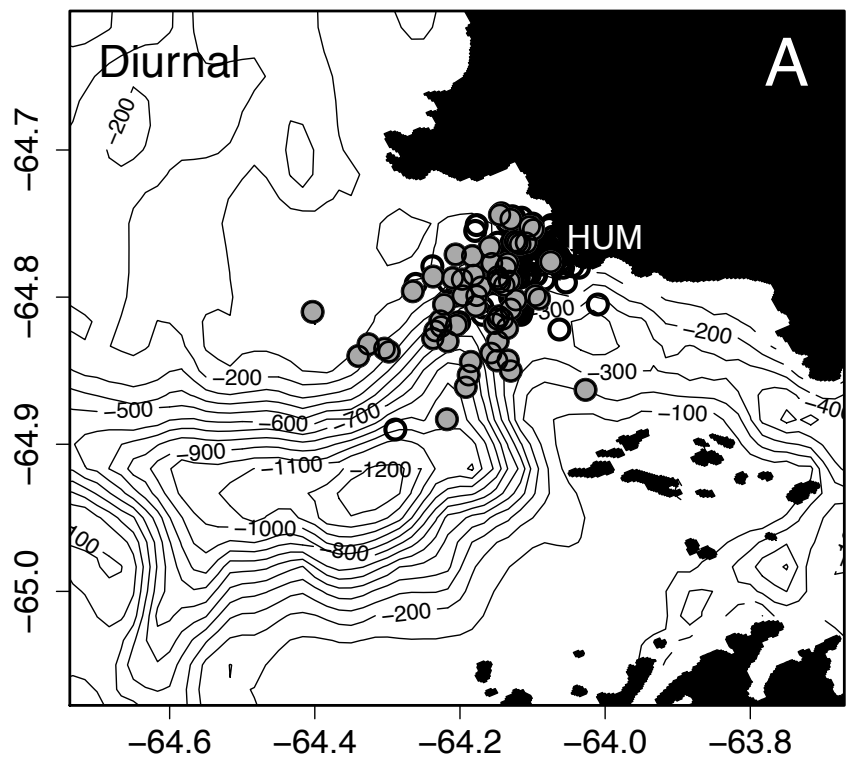
First Field Season Results

Currents integrated over the top 100m of the water column as measured by a Slocum Glider AUV.



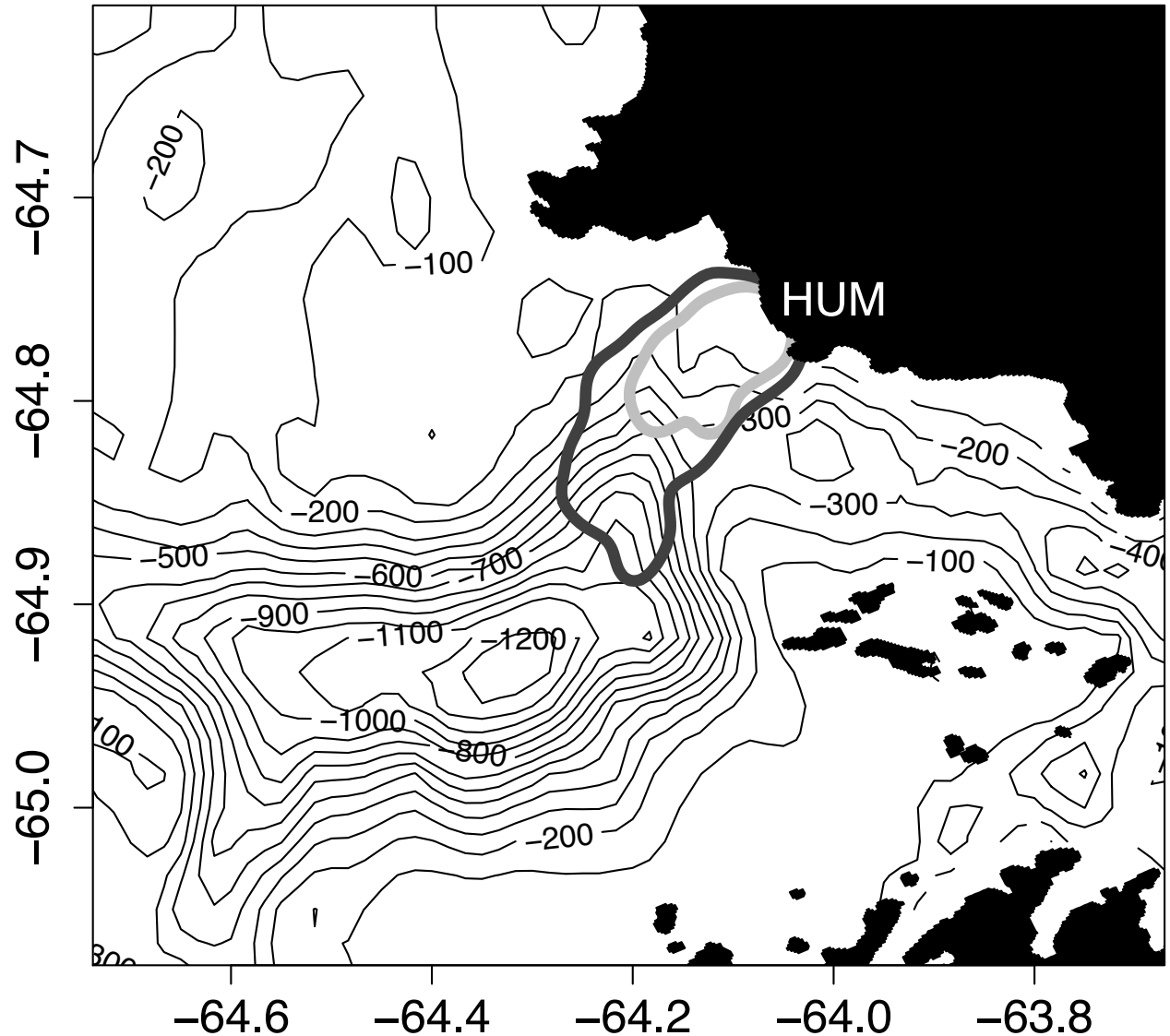
First Field Season Results

During diurnal tides, Adélie penguins from Humble Isl. forage much closer to land than during semi-diurnal tides.



For ten seasons (2001-2011), 95% of Adélie penguin GPS locations were located within the grey contour during diurnal tides and located within the black contour during semi-diurnal tides.

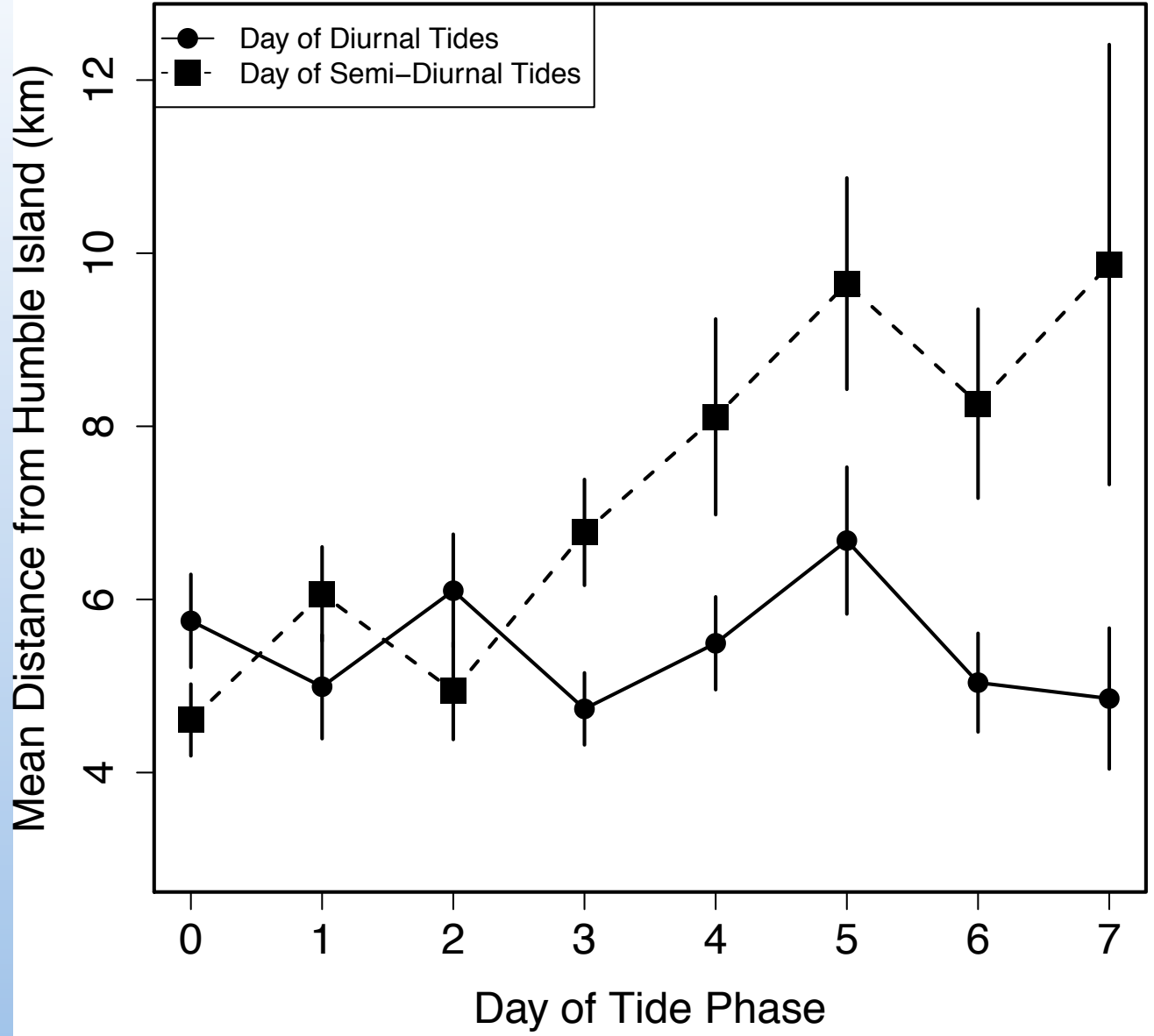
Adélie penguins tended to be further over Palmer Canyon during semi-diurnal tides.



First Field Season Results

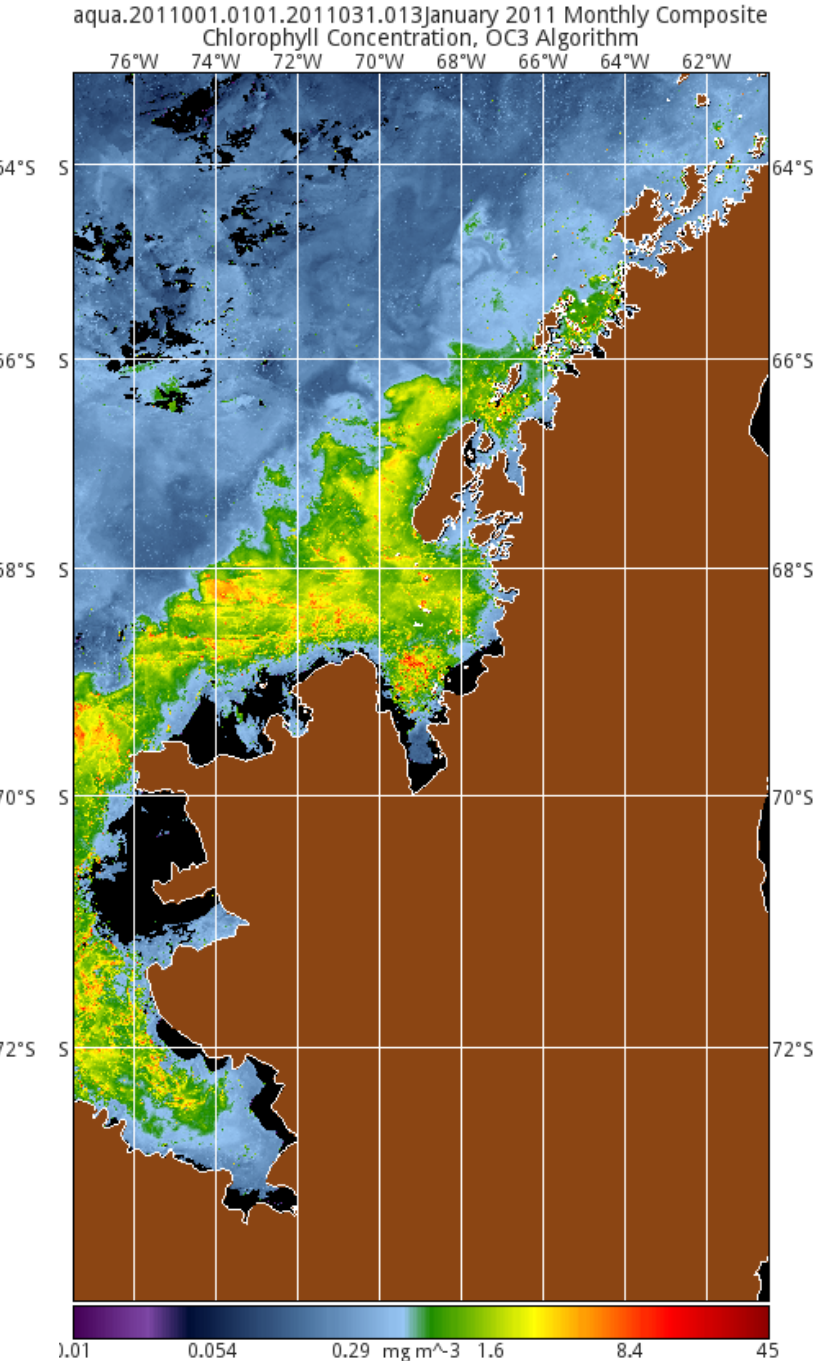
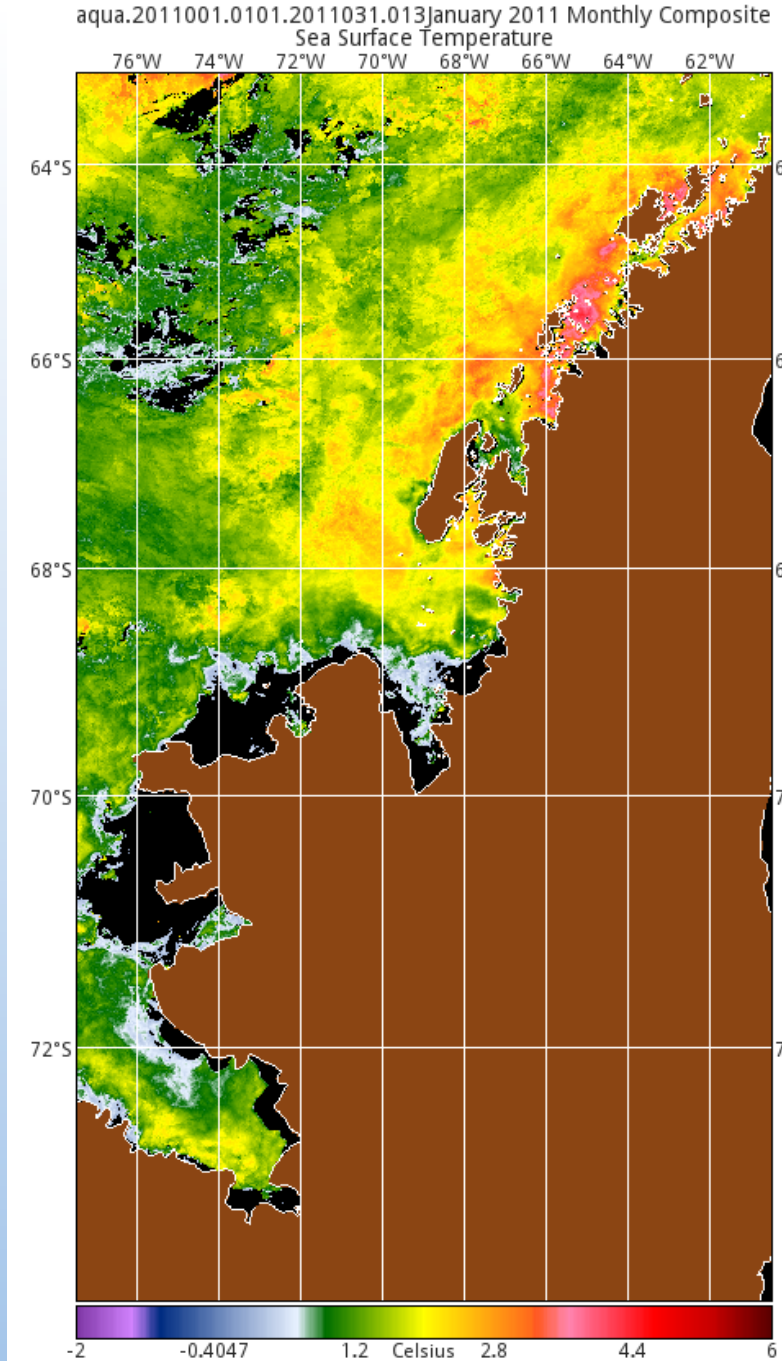
The Adélie penguin mean distance from Humble Island for each day of a given tidal phase for diurnal and semi-diurnal tides.

Bars represent twice the standard error of the mean.



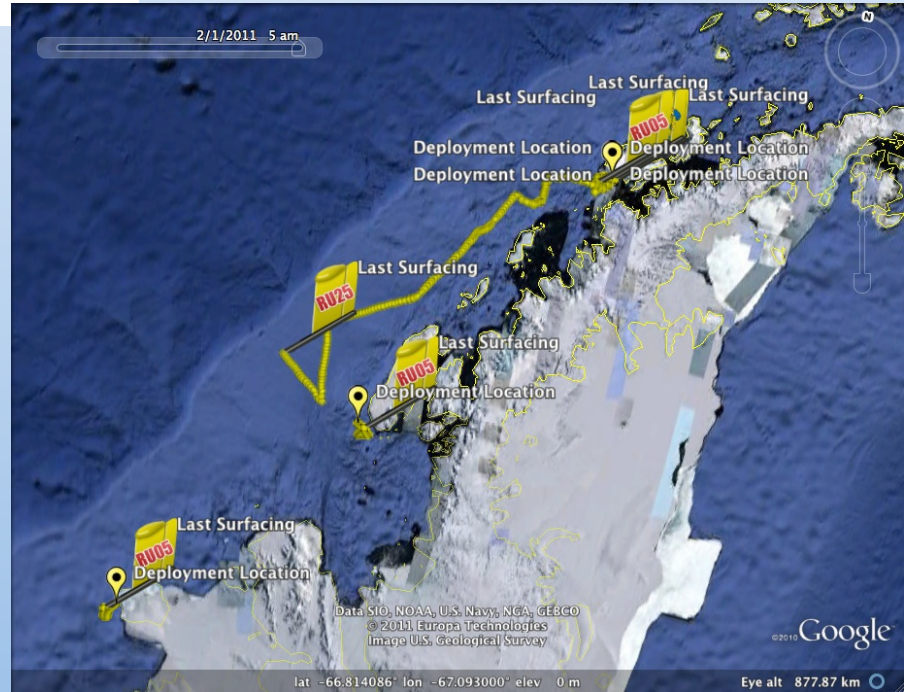
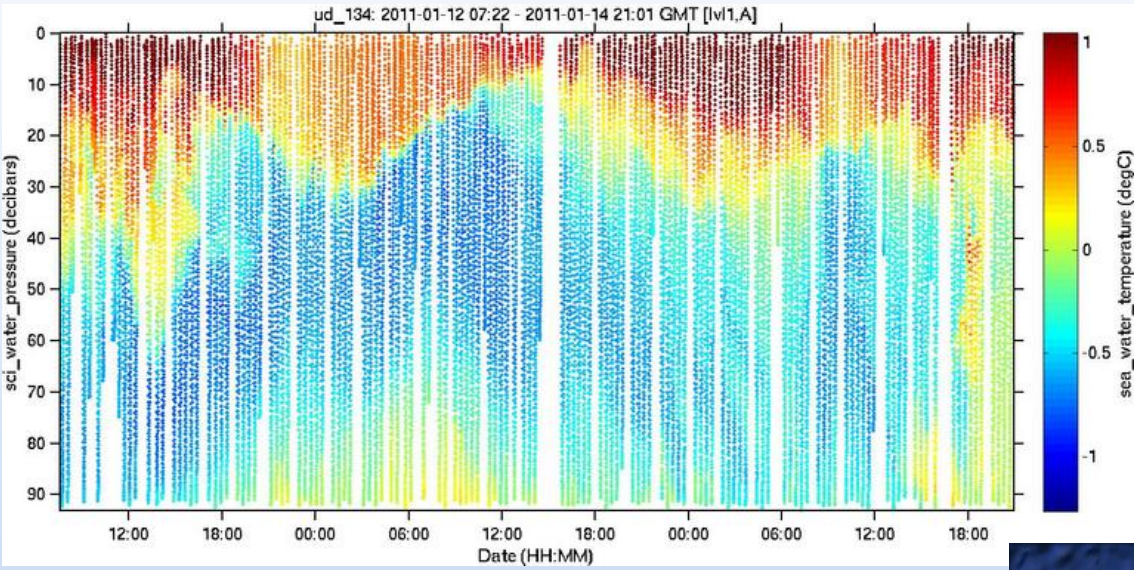
Future Directions for second field season

Analyze remote sensing data from first field season (waiting for reprocessing)



Future Directions for second field season

Incorporate vertical dimension from REMUS and Gliders with penguin foraging



Summary

- **Large Scale Remote Sensing/Modeling Results**
 - **MaxEnt models show interesting trends**
 - **Merge with Climate Models**
- **First Field Season**
 - **Dynamic planning based on penguin location**
- **Results of First Field Season**
 - **Foraging of penguin species are spatially segregated**
 - **Long-term affect of the tide**
 - **Likely pushing krill around**
- **Future Analyses and Field Season**
 - **Analyze local high res satellite data**
 - **Increase mapping of krill**
 - **Incorporate vertical information from REMUS and Gliders**